Indicator: Forest Disturbances: Fire, Insects and Disease (113)

Fires, insects, and disease play key roles in shaping the biotic structure of forest ecosystems (Lorimer, 2001; Seymour et al., 2002). While they all occur naturally, they can be influenced by other variables such as management decisions, air pollutants, and variations in climate. For example, trees weakened by pollutants might be more susceptible to attack by pathogens.

This indicator, developed by the Heinz Center (2003), tracks trends in the occurrences of fires, insect outbreaks, and diseases or parasites. The fire indicator is based on data from the National Interagency Fire Center (NIFC) and the Fire and Aviation Management branch of the U.S. Department of Agriculture (USDA) Forest Service. Together, these sources have compiled national fire acreage statistics for every year since 1916, based on reports from various federal and state agencies. The insect and disease indicators are based on data from the Forest Service Forest Health Monitoring (FHM) program, which is a survey-based program that has operated since the late 1940s. FHM conducts aerial surveys in order to determine the number of acres of forest with visible defoliation or mortality, then conducts additional surveying on the ground as needed to determine the identity of the insect or other parasite causing damage.

What the Data Show

Wildfire acreage has declined from a peak of more than 50 million acres per year in the 1930s (Figure 113-2) to 2 to 7 million acres per year (Figure 113-1), largely due to fire suppression policies (The Heinz Center, 2003). However, there has been a slight increase in fires in recent decades, with 8.4 million acres of forest burned in 2000 (Figure 113-1). Insect damage from five major insect pests affects between 8 and 46 million acres per year (Figure 113-1). The noticeable fluctuations are primarily a result of population cycles of gypsy moth and southern pine beetle (for example, the large spike in 1986 reflects a peak population of southern pine beetle). Data for two major parasites, fusiform rust and dwarf mistletoe, are available only for the past several years, but the total acreage affected is 43 to 44 million acres (Figure 113-1) (The Heinz Center, 2003).

Indicator Limitations

- This indicator does not distinguish between forest fires, other wildfires, and prescribed burns. It also does not track the intensity of the fires.
- Data are not available on forests affected by insects or diseases other than those listed above.
- Some insects can cause widespread damage before it is apparent from aerial surveys.
- Disease data are annual figures, but are based on state surveys that may only take place every 5 to 20 years. Thus, the 2002 disease figures include the most recent survey data from every state, but for some states, these data are as old as the 1980s.

Data Sources

Fire data: (1) Data 1960-present: National Interagency Fire Center (NIFC), http://www.nifc.gov/stats/wildlandfirestats.html. (2) Data 1916-1960: USDA Forest Service, Fire and Aviation Management. NIFC and the Forest Service compiled their annual totals from statistics reported by several state and federal agencies.

Insect and disease data: USDA Forest Service, *Forest Insect and Disease Conditions in the United States – 2003* and similar reports for previous years (http://www.fs.fed.us/foresthealth/current_conditions.shtml). [Pre-1998 insect data are only available as a

bar graph; total data availability to be determined, based on ongoing conversations with the Forest Service.]

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USDA Forest Service. 2004. Forest Insect and Disease Conditions in the United States – 2003. Washington, DC: USDA Forest Service, Forest Health Protection. http://www.fs.fed.us/foresthealth/current_conditions.shtml.

Graphics

Figure 113-1. Fire, insects, and disease: Recent trends (1979-2000)

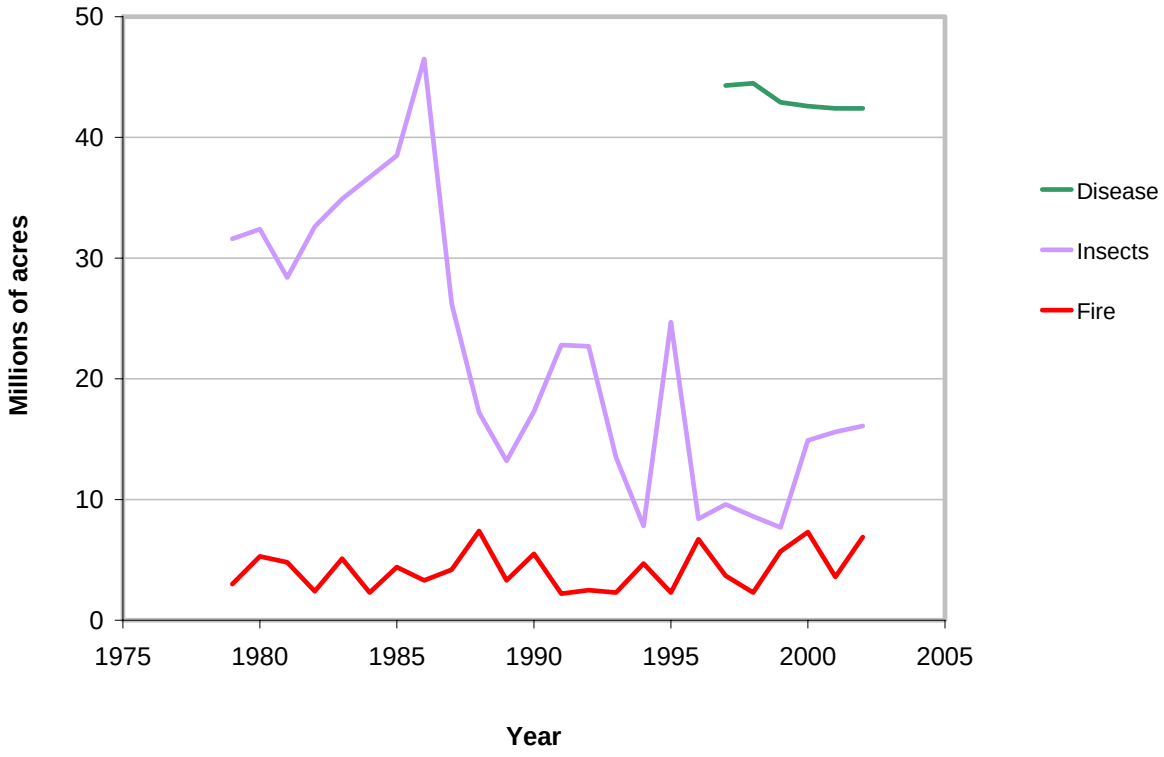
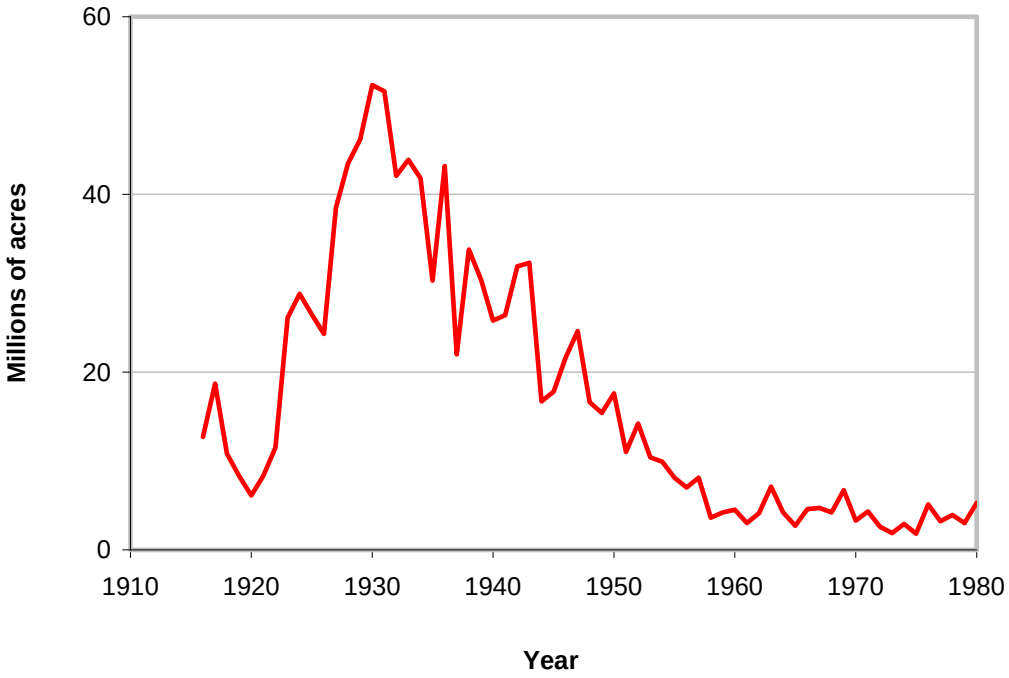


Figure 113-2. Historic wildfire acreage (1916-1980)



R.O.E. Indicator QA/QC

Data Set Name: FOREST DISTURBANCE
Indicator Number: 113 (89664)
Data Set Source: USDA Forest Service
Data Collection Date: irregular: 1916 - 2002
Data Collection Frequency: variable
Data Set Description: Forest Disturbance
Primary ROE Question: What are the trends in the ecological processes that sustain the Nation's ecological systems?

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

(1) Fire data. The Heinz Center (2003) does not present explicit documentation of the methods used to determine the number of acres burned every year. Several federal and state agencies collect fire data independently. Since 1960, the National Interagency Fire Center (NIFC) has compiled these data (NIFC, 2002); older data were compiled by individuals at the Fire and Aviation Management branch of the USDA Forest Service (Forest Service, Andrea Wojtasek and Marian Villasenor, personal communication, 2004). Neither NIFC nor the Forest Service can provide a full accounting for field methods that may have been used for this indicator.

(2) Insect data. The USDA Forest Service has collected insect data through aerial surveys conducted by its regional offices under the auspices of its Forest Health Monitoring (FHM) program. These data include the five insects covered under this indicator. FHM conducts the surveys following a set of established guidelines regarding survey timing, flight patterns, and measurement scale (see T3Q1). Since the 1940s, surveying has relied on airborne observers who sketch visible damage onto topographic map templates. Thus, aerial surveying requires a subjective assessment of whether defoliation or mortality is sufficiently visible and severe to constitute a "disturbed area." Forest Service analysts acknowledge the coarseness of this methodology, but they believe it represents the most economical and efficient way to measure broad trends across the national landscape (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml). In some cases, more recent data come from new digital GIS sketching technology that the Forest Service has developed to improve the accuracy of the aerial survey process (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml; http://www.fs.fed.us/foresthealth/publications/id/id_tech.html). FHM provides a list of general references at http://fhm.fs.fed.us/fact/index.htm.

FHM supplements aerial survey data with ground surveying data (Forest Service, Ken Stolte, personal communication, 2004). However, for the broad national data in this indicator, ground surveying most likely represents a means of simply confirming the insect(s) to which damage visible from the air can be attributed. This ground surveying is conducted as needed, and does not necessarily follow a standard set of procedures.

Beginning in the late 1990s, FHM ground surveying was incorporated into the Forest Service's Forest Inventory and Analysis (FIA) ground monitoring program (FHM Fact Sheet: http://www.na.fs.fed.us/spfo/fhm/fact/03/dm.pdf). More documentation of FIA field methods can be found at the links noted under the following section on "disease data."

(3) Disease data. The Forest Service has collected comprehensive national data for the two major parasites studied under this indicator (fusiform rust and dwarf mistletoe) since 1997. Data for this indicator were collected by FHM prior to the late 1990s (see description of FHM above). Beginning in the late 1990s, disease data were collected through collaboration between FHM and the Forest Service's Forest Inventory and Analysis (FIA) program, which has conducted nationwide ground inventories of forest characteristics (e.g., size, age, density) since the 1940s. FIA collects data from points on a rectangular or hexagonal (since 1998) national grid, following a three-phase approach in which basic measurements take place at many sites, but only a subset of sites (evenly spaced across the grid) are used for more intensive monitoring. Detailed disease data come from the most intensive monitoring (Phase 3) sites, which are spaced at approximately one site per 96,000 acres (http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf). FIA follows standard methodologies for ground sampling: see http://fia.fs.fed.us/library/field-guides-methods-proc/ (field methods); http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm (plot size and design); and http://fia.fs.fed.us/library/Factsheets/Sampling%20and%20Plot%20Design.doc (plot design). In addition, FHM provides a list of general references supporting its overall program (http://fhm.fs.fed.us/fact/index.htm). A discussion of FIA's scientific validity can be found in a recent special issue of the Journal of Forestry (vol. 97, no. 12, 1999).

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

(1) Fire data. Neither the Heinz Center (2003) nor the Forest Service provides specific information about sampling design. NIFC and Forest Service annual fire summaries are based on reports from a collection of federal and state agencies, and these individual reports are not readily available. (2) Insect data. The Forest Service website contains basic information about the design of the aerial surveys used to assess insect damage (see also T3Q1). Forest Service officials design aerial surveys based on the resolution of the map they wish to obtain (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml), and follow specific flight patterns to ensure thorough spatial coverage (http://www.fs.fed.us/r1-r4/spf/fhp/aerial/index.html). FHM employs ground surveying as needed to identify particular insects or other parasites causing damage noted from the air. FHM survey design represents several decades of survey experience. (3) Disease data. Historic disease data were collected by FHM as described above. Recent data were obtained following a standard sample design used by FIA for several decades. FIA s monitoring plan consists of three analytical phases. In Phase 1, the phase of lowest detail, FIA analyzes aerial photographs and satellite imagery to determine general characteristics of forest cover. FIA also uses Phase 1 imagery to plot a grid of locations for ground monitoring in Phase 2. Phase 3 represents a more detailed ground assessment than Phase 2; this monitoring takes place at a subset of Phase 2 locations. Data for this indicator come from Phase 3 sites. FIA has published fact sheets to support and explain its three-tiered sampling methodology: Detailed description of phases: http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf Sampling and plot design: http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling and Plot Design.pdf A discussion of the scientific validity of FIA s sample design can be found in a recent special issue of the Journal of Forestry (vol. 97, no. 12, 1999).

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

(1) Fire data. The Heinz Center (2003) and online NIFC materials do not document either the exact nature of raw data or the analytical processes that may be used to transform it. (2) Insect data. Each FHM aerial survey provides a map of insect-damaged areas, which Forest Service

analysts must then transform into figures of total acreage. The digital mapping equipment used to conduct more recent surveys (http://www.fs.fed.us/foresthealth/publications/id/id_tech.html) can calculate acreage automatically. However, most of the insect data included in this indicator are a product of hand-surveying, for which data transformation methods were not identified. [Additional information may be available here, based on ongoing communications with the Forest Service.] (3) Disease data. FIA follows standard statistical protocols to transform ground measurements into values of total acreage. These FIA protocols are supported by sources documented in T3Q1.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The forest disturbance indicator offers a useful assessment of the diversity and biological balance of the nation's forests. While fire, insects, and disease occur naturally, all three of these factors can impact the health of the entire forest ecosystem. (1) Fire data. The fire indicator data represent a compilation of information from several state and federal agencies. According to the Forest Service, these typically include acreage figures reported to the United States Department of Agriculture, Forest Service, by its field offices, the State Forester (or a comparable state official) of each of the 50 states, the officials of Puerto Rico and Guam, the Department of the Interior, and the Tennessee Valley Authority (Forest Service, 1992; full citation below). Thus, the fire component of this indicator includes data from public and private lands in all 50 states. In addition, this component of the indicator includes data from grassland and shrubland fires, which allows it to offer a more complete picture of the total extent of wildfires across the nation (Heinz Center, 2003). Forest Service. 1992. 1980-1994 Wildfire Statistics. USDA Forest Service, State and Private Forestry, Fire and Aviation Management Staff. January 1992. (2) Insect data. The use of aerial survey data ensures that this component of the indicator covers a broad spatial range. Aerial surveying is not an exact measurement, as it has historically required a subjective human judgment of whether an area appears sufficiently damaged to warrant inclusion in a hand-drawn map. Aerial surveying also does not reveal damage from every major insect parasite. However, aerial surveying does represent a simple way to create a broad annual picture of the damage created by certain insects with highly visible defoliation effects including the five major insects for which information is included in this indicator. (3) Disease data. The data available to support this component of the indicator are limited to two plant diseases, with coverage beginning in 1997. Nonetheless, while disease data do not provide a great temporal range or a full accounting of all diseases affecting the nation's forests, this component of the indicator does provide a general picture of recent trends in forest disease, and some basis for comparison with other forms of forest disturbance (fire and insects).

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

This indicator does not demonstrate any bias towards sensitive populations or ecosystems. Because this indicator aims to give an overall picture of forest health in the United States, it is important that the indicator examine sensitive ecosystems in the proportion in which they naturally happen to occur. For this reason, the Forest Service typically conducts aerial surveys (FHM) and ground monitoring (FIA) using a grid-like methodology, so as to give equal weight to equal areas. This indicator presents data in the form of national totals, without any indication of what states or regions might be affected most by any of these forms of disturbance. Thus, this indicator cannot be used to characterize particular regions or ecoregions.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

This indicator does not include reference points or baseline values that unambiguously reflect the state of the environment. With no disease data earlier than 1997, this indicator provides no historical basis for comparison of current disease conditions. Insect and forest data cover longer periods of time, but neither of these components includes historical data that can unquestionably be considered representative of a natural or undisturbed state.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

(1) Fire data. Overall fire data represents a compilation of information reported by several government agencies (see T3Q2), each of which may have its own methods of measuring or estimating acreage burned. The National Interagency Fire Center (NIFC) has made summary statistics available to the public for 1960-2003, but the NIFC website does not include any information about measurement or estimation techniques. The Heinz Center obtained historic (1916-present) data from individuals at the Fire and Aviation Management branch of the USDA Forest Service (Forest Service, Andrea Wojtasek and Marian Villasenor, personal communication, 2004), but the Forest Service has not provided direct documentation of sampling or analytical methods either. The Forest Service can provide summary tables, but does not have a full library or record of the many state and federal reports that were consulted at the time annual statistics were compiled. (2) Insect data. The Heinz Center (2003) reports that insect data are derived from aerial surveys. This is consistent with The Forest Service s 2003 Report on Sustainable Forests (technical note for indicator 15: http://www.fs.fed.us/research/sustain/documents/Indicator%2015/Indicator%2015.pdf), which notes that the Forest Service has conducted aerial surveys for insect damage since 1947, with full national coverage beginning around 1979. The Forest Service conducted these surveys through its Forest Health and Monitoring (FHM) Program, which has published a general program description at http://www.na.fs.fed.us/spfo/fhm/fact/03/dm.pdf. FHM has also published a general description of guidelines for aerial detection surveys, including mapping grids (http://www.fs.fed.us/foresthealth/publications/id/id_guidelines.html). More specific documentation may be obtained from each of the Forest Service regional offices, which directly oversee the surveying program (http://www.fs.fed.us/foresthealth/regional_offices.html). Useful information from Forest Service regional sites includes contacts (all regions), a description of survey timing and flight patterns (http://www.fs.fed.us/r1-r4/spf/fhp/aerial/index.html), a discussion of mapping scale (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml), and more general surveying guidelines (http://www.fs.fed.us/r5/spf/about/aerial-survey-guidelines.shtml). Aerial data are supplemented by FHM ground surveying in order to identify the parasite(s) responsible for damage that is visible from the air. These ground surveys are basically conducted as needed, not necessarily following a single consistent sampling methodology (Ken Stolte, Forest Service, personal communication, 2004). (3) Disease data. The Forest Service collected data on the two diseases included in this indicator (fusiform rust and dwarf mistletoe) through collaboration between FHM and the Forest Service s Forest Inventory and Analysis (FIA) program, which has conducted nationwide ground inventories of forest characteristics (e.g., size, age, density) since the 1940s. This collaboration began in 1990, as FIA started to incorporate tree health criteria into its nationwide Phase 3 ground monitoring program (http://hrcweb.nevada.edu/forestry/index.html). The disease data for this indicator, with coverage from 1997 to 2002, are the product of FIA s collection methods. FIA collects data from points on a rectangular or hexagonal (since 1998) national grid, following a three-phase approach in which basic measurements take place at many sites, but only a subset of sites (evenly spaced across the grid) are used for more intensive monitoring. Detailed disease data come from the most intensive monitoring (Phase 3) sites. FIA follows standard methodologies for ground sampling: see

http://fia.fs.fed.us/library/field-guides-methods-proc/ (field methods); http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm (plot size and design); and http://fia.fs.fed.us/library/fact-sheets/data-collections/Sampling and Plot

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

(1) Fire data. The Heinz Center (2003) reports that it obtained fire data from several sources: A database maintained by the National Interagency Fire Center (NIFC), located online at http://www.nifc.gov/stats/wildlandfirestats.html. This database lists the total number of acres burned each year from 1960 to 2003. NIFC data represents a compilation of data from several government agencies (USDA Forest Service, Bureau of Land Management, Bureau of Indian Affairs, U.S. Fish and Wildlife Service, National Park Service, and state agencies), but only summary figures are reported in the database, not figures from individual agencies. The U.S. Forest Service. The Fire and Aviation Management branch of the Forest Service has compiled annual fire statistics from reports issued by several state and federal agencies for their respective jurisdictions. A typical list of reporting agencies includes [Forest Service] field offices, the State Forester (or a comparable state official) of each of the 50 states, the officials of Puerto Rico and Guam, the Department of the Interior, and the Tennessee Valley Authority (Forest Service, 1992). Figures are available for 1916-present. Data are not available online, but summary figures may be obtained from Marian Villasenor at Fire and Aviation Management, mvillasenor@fs.fed.us. The Forest Service does not have a full library or record of every state or federal report that was consulted at the time each year s summary statistics were compiled. Forest Service. 1992. 1980-1994 Wildfire Statistics. USDA Forest Service, State and Private Forestry, Fire and Aviation Management Staff. January 1992. (2) The Heinz Center (2003) cites the Forest Service s Forest Health Conditions website (http://www.fs.fed.us/foresthealth/current_conditions.shtml) as a source of recent insect data. This site contains several annual reports, the most recent of which is Forest Insect and Disease Conditions in the United States 2003 (Washington, DC: USDA Forest Service, August 2004), located at http://www.fs.fed.us/foresthealth/publications/annual_i_d_conditions/ConditionsReport_03_final.pdf. This report includes numerical data on annual acreage affected by several insects for the period 1999-2003; for the five insects included in the Heinz indicator, this report also includes bar graphs with annual acreage figures for the period 1979-2003 (1940-2003 for the gypsy moth). The recent reports available online do not provide numerical data for insect acreage prior to 1999. However, the Heinz Center notes that it was able to obtain Insect and Disease Conditions reports from the Forest Service for 1979-83, 1984, 1985, 1986, 1987, 1993, 1997, 1998, and 1999 (Kent Cavender-Bares, Heinz Center, personal communication, 2004). (3) Disease data. The Heinz Center (2003) reports that it obtained 1997-2002 data on the two diseases covered by this indicator (fusiform rust and dwarf mistletoe) from the Forest Health Conditions website (http://www.fs.fed.us/foresthealth/current_conditions.shtml). Data are included within the annual reports posted at this site, as noted above. These reports list acreage affected, not raw data from individual ground monitoring sites. [These reports do not cover every state in every year. This is consistent with the old FIA methodology, where each ground site was only visited every 5 to 10 years. Thus, annual data come from measurements that were not taken every year.] (4) The numerical data represented in the graphics for this indicator may be obtained online from the Heinz Center (http://www.heinzctr.org/ecosystems/forest/datasets/forest_disturbance_recent_trends.shtml; http://www.heinzctr.org/ecosystems/forest/datasets/forest_disturbance_historic_trends.shtml).

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?

This indicator s reliance on historical measurements limits reproducibility, even in cases where good documentation of survey design exists. For example, aerial survey results reflect subjective judgments and sketches made in real-time. Thus, insect damage assessments can only be reproduced to the extent that original sketches may still be available for re-analysis. For disease data, FIA describes field sampling methods in great detail. However, FIA and FHM only appear to provide access to metadata (overall acreage affected), not raw data from individual monitoring stations. FIA also maintains the confidentiality of its ground monitoring sites (FIA Fact Sheet: http://fia.fs.fed.us/library/fact-sheets/data-collections/Phase2_3.pdf). In the case of fire data, the Heinz Center and the government agencies that collected the data do not provide online access to raw data or documentation of survey design.

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

The various agencies responsible for fire data provide no online documentation of collection methods or related quality assurance/quality control procedures. The Forest Service has published general quality control procedures for the aerial surveys used to collect insect data for this indicator (Aerial Survey Standards. Forest Health Monitoring Program, October 1999. http://www.fs.fed.us/foresthealth/publications/id/standards_1099.pdf). This document indicates that more specific QA/QC information can be obtained from Forest Service regional offices, which directly oversee aerial surveys. The website http://www.fs.fed.us/foresthealth/regional_offices.html includes links to regional offices. Although some regional office websites have not posted extensive information about surveying online, all of these sites list contacts who may be able to provide more information. For disease data, several of the Fact Sheets and Field Guides in FIA s online library contain information about quality assurance and quality control in ground sampling (http://fia.fs.fed.us/library/). One document in particular, http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf (FIA Fact Sheet Series: Quality Assurance) provides a thorough discussion of many aspects of the QA/QC process.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

(1) Fire data. This indicator does not require temporal manipulation, since annual figures appear to be derived from annual acreage data reported by state and federal agencies. NIFC and the Forest Service maintain databases of annual summary figures, but these databases do not include information about the spatial aspects of data collection or manipulation. (2) Insect data. This component of the indicator requires no temporal manipulation, as it is reported on an annual basis from full aerial surveys conducted by the Forest Service. This component of the indicator does not require complicated spatial generalization or extrapolation either. The Forest Service surveys all forest area each year, so figures for total acreage basically represent the sum of all its surveys. (3) Disease data. Spatially, FIA uses a set of standard statistical procedures to convert ground measurements into figures of total acreage affected by a particular disease. While this spatial extrapolation does introduce uncertainty into the data, FIA has chosen the number of ground locations (i.e., the size of its probability sample) to ensure that uncertainty remains within a specific range (see T4Q2). Temporally, this component of the indicator represents a great deal of projection, since annual figures are based on state surveys that are only performed every 5 to 20 years. There is no attempt to project year-to-year changes using statistical methods; instead, old

data are just included as is, even if the data may no longer be accurate. This does not appear to be an appropriate method of deriving annual disease figures.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

(1) Fire data. Neither the Heinz Center nor the agencies responsible for collecting or compiling fire data
have published uncertainty data for this component of the indicator. (2) Insect data. The Forest Service does not explicitly quantify the uncertainty associated with its aerial surveying methods, although it does provide a discussion of mapping resolution/scale (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml). (3) Disease data. The Forest Service s National Report on Sustainable Forests 2003 (http://www.fs.fed.us/research/sustain) does not present uncertainty measurements for the disease measurements upon which this indicator is based. However, FIA s QA/QC fact sheet specifically mentions that field data are always accompanied by uncertainty measurements (http://fia.fs.fed.us/library/fact-sheets/data-collections/QA.pdf). FIA s database documentation provides a general discussion of error in ground measurements like those used to collect recent (since the late 1990s) insect and disease data for this indicator (http://ncrs2.fs.fed.us/4801/fiadb/fiadb_documentation/fiadb_chapter2.htm). According to this source, FIA designs its inventories to meet specified sampling errors at the 67 percent confidence limit (one standard error). By Forest Service mandate, sampling error for area must not exceed 3% per 1 million acres; aerial design surveys like the one used for this indicator are designed accordingly. This source also quantifies the degree to which error may be magnified on a local scale, suggesting that this indicator is best suited to broad trends on a national scale.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Several sources of uncertainty and variability accompany this indicator, some of which may reduce its utility as a broad, national-level measuring tool. (1) This indicator includes fire data originally collected by several state and federal agencies. The agencies that compiled the data used in this report (NIFC-online; Forest Service-personal communication) do not have extensive information about methods, measuring standards, and the extent (or possible overlap) of the geographic jurisdictions of the various government agencies that collect raw data. There may be significant sources of uncertainty here, but the lack of supporting information makes the impact of this uncertainty difficult to assess. (2) Aerial surveys for insect damage have historically relied on human perception to determine the size of the area deemed disturbed. Because this indicator aims to measure very broad national trends, it does not require exact numbers or a high degree of local detail. The Forest Service's Region 6 website discusses this source of uncertainty (http://www.fs.fed.us/r6/nr/fid/as/as-facts.shtml) and provides a reference containing a more in-depth discussion: Klein, W.H., S. Tunnock, J.G.D. Ward, and J.A.E. Knopf. 1983. Aerial Sketchmapping. In: Forest Insect and Disease Survey Methods Manual, USDA Forest Service, Forest Pest Management, Methods Application Group, Davis, Calif., 15 pp. (3) By deriving a national acreage figure from ground samples conducted several miles apart (one sample per 96,000 acres, following a grid), FIA s Phase 3 sampling methodology may introduce uncertainty into recent data, particularly on a local scale (see T4Q2). FIA designs its procedures to keep error within specific bounds. However, because annual figures for the disease indicator are derived from non-annual state survey data (the 2003 disease data include information from some FIA state surveys that were conducted as early as the 1980s), the reported totals are actually of rather limited utility as a metric of true year-to-year trends. (4) The main source of variability in this indicator is natural. Fires can vary with weather patterns (e.g., droughts, lightning). Insects and

diseases may fluctuate based on natural population cycles; for example, the Heinz Center (2003) attributes much of the insect variability over the last 20 years to population cycles involving the gypsy moth and southern pine beetle. However, this natural variability does not diminish the utility of the indicator. Instead, it provides one explanation for some of the year-to-year variations apparent in the indicator graphic.

T4Q4 Are there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

(1) This indicator does not differentiate among true wildfires and prescribed burns. [However, NIFC does have figures for prescribed burn acreage for the period 1995-2000 (http://www.nifc.gov/stats/).] (2) This indicator requires some simplification: an area is either disturbed or not disturbed. In the case of fire, the indicator cannot account for the intensity of fire damage. For insects and disease, the indicator cannot quantify how heavily an area has been affected; it can only report how many acres have either met a Forest Service threshold for the percentage of trees damaged, or just shown evidence that a particular parasite is present (in the case of ground surveying for disease). (3) Data are limited to five insects and two diseases. Thus, this indicator does not represent the full extent to which the nation's forests are affected by insects and disease. In particular, this indicator does not quantify damage associated with the hemlock wooly adelgid, whose damage may not be detected through aerial surveys until several years after the damage has occurred (Heinz Report, 2003). (4) The indicator only includes disease data from 1997 to 2002. Thus, it currently lacks a historical baseline for comparison of recent trends in disease prevalence. (5) Annual disease data are based on non-annual state surveys. Insect data may be similarly limited, since historically, FHM has not had a consistent methodology for completing a full national aerial survey every year. Some state surveys were last completed in the late 1980s or early 1990s. This may represent a significant limitation to this indicator.